PB84-211028

Hazardous Waste Landfill Research: U.S.E.P.A. (United States Environmental Protection Agency) Program

(U.S.) Municipal Environmental Research Lab.
Cincinnati, OH

Jun 84

U.S. Department of Commerce
National Technical Information Service
NTIS

PB84-211028

EPA-600/D-84-171
June 1984

HAZARDOUS WASTE LANDFILL RESEARCH

U.S.E.P.A. PROGRAM

Norbert B. Schomaker

U. S. Environmental Protection Agency
Municipal Environmental Research Laboratory
Solid and Hazardous Waste Research Division
Cincinnati, Ohio 45268

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/D-84-171		PB84 211028

4. TITLE AND SUBTITLE	5. REPORT DATE
HAZARDOUS WASTE LANDFILL RESEARCH U.S.E.P.A. Program	June 1984
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Norbert B. Schomaker	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Municipal Environmental Research Laboratory--Cin., OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268	10. PROGRAM ELEMENT NO. BRD1A
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory--Cin., OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES

Project Officer: Norbert B. Schomaker (513) 684-7871

16. ABSTRACT

The hazardous waste land disposal research program is collecting data necessary to support implementation of disposal guidelines mandated by the "Resource Conservation and Recovery Act of 1976" (RCRA) PL 94-580. This program relating to the categorical areas of landfills, surface impoundments, and underground mines encompasses state-of-the-art documents, laboatory analysis, economic assessment, bench and pilot studies, and full-scale field verification studies. Over the next five years the research will be reported as Technical Resource Documents in support of the RCRA Guidance Documents. These documents will be used to provide guidance for conducting the review and evaluation of land disposal permit applications. This paper will present an overview of this program and will report the current status of the work.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	24
	20. SECURITY CLASS *(This page)*	22. PRICE
	UNCLASSIFIED	

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

INSTRUCTIONS

1. **REPORT NUMBER**
Insert the EPA report number as it appears on the cover of the publication.

2. **LEAVE BLANK**

3. **RECIPIENTS ACCESSION NUMBER**
Reserved for use by each report recipient.

4. **TITLE AND SUBTITLE**
Title should indicate clearly and briefly the subject coverage of the report, and be displayed prominently. Set subtitle, if used, in smaller type or otherwise subordinate it to main title. When a report is prepared in more than one volume, repeat the primary title, add volume number and include subtitle for the specific title.

5. **REPORT DATE**
Each report shall carry a date indicating at least month and year. Indicate the basis on which it was selected *(e.g., date of issue, date of approval, date of preparation, etc.)*.

6. **PERFORMING ORGANIZATION CODE**
Leave blank.

7. **AUTHOR(S)**
Give name(s) in conventional order *(John R. Doe, J. Robert Doe, etc.)*. List author's affiliation if it differs from the performing organization.

8. **PERFORMING ORGANIZATION REPORT NUMBER**
Insert if performing organization wishes to assign this number.

9. **PERFORMING ORGANIZATION NAME AND ADDRESS**
Give name, street, city, state, and ZIP code. List no more than two levels of an organizational hirearchy.

10. **PROGRAM ELEMENT NUMBER**
Use the program element number under which the report was prepared. Subordinate numbers may be included in parentheses.

11. **CONTRACT/GRANT NUMBER**
Insert contract or grant number under which report was prepared.

12. **SPONSORING AGENCY NAME AND ADDRESS**
Include ZIP code.

13. **TYPE OF REPORT AND PERIOD COVERED**
Indicate interim final, etc., and if applicable, dates covered.

14. **SPONSORING AGENCY CODE**
Insert appropriate code.

15. **SUPPLEMENTARY NOTES**
Enter information not included elsewhere but useful, such as: Prepared in cooperation with, Translation of, Presented at conference of, To be published in, Supersedes, Supplements, etc.

16. **ABSTRACT**
Include a brief *(200 words or less)* factual summary of the most significant information contained in the report. If the report contains a significant bibliography or literature survey, mention it here.

17. **KEY WORDS AND DOCUMENT ANALYSIS**
(a) DESCRIPTORS - Select from the Thesaurus of Engineering and Scientific Terms the proper authorized terms that identify the major concept of the research and are sufficiently specific and precise to be used as index entries for cataloging.

(b) IDENTIFIERS AND OPEN-ENDED TERMS - Use identifiers for project names, code names, equipment designators, etc. Use open-ended terms written in descriptor form for those subjects for which no descriptor exists.

(c) COSATI FIELD GROUP - Field and group assignments are to be taken from the 1965 COSATI Subject Category List. Since the majority of documents are multidisciplinary in nature, the Primary Field/Group assignment(s) will be specific discipline, area of human endeavor, or type of physical object. The application(s) will be cross-referenced with secondary Field/Group assignments that will follow the primary posting(s).

18. **DISTRIBUTION STATEMENT**
Denote releasability to the public or limitation for reasons other than security for example "Release Unlimited." Cite any availability to the public, with address and price.

19. & 20. **SECURITY CLASSIFICATION**
DO NOT submit classified reports to the National Technical Information service.

21. **NUMBER OF PAGES**
Insert the total number of pages, including this one and unnumbered pages, but exclude distribution list, if any.

22. **PRICE**
Insert the price set by the National Technical Information Service or the Government Printing Office, if known.

U.S. EPA Hazardous Waste Landfill Research Program

Norbert B. Schomaker
U. S. Environmental Protection Agency
Municipal Environmental Research Laboratory
Solid and Hazardous Waste Research Division
Cincinnati, Ohio

ABSTRACT

The hazardous waste land disposal research program is collecting data necessary to support implementation of disposal guidelines mandated by the "Resource Conservation and Recovery Act of 1976" (RCRA) PL 94-580. This program relating to the categorical areas of landfills, surface impoundments, and underground mines encompasses state-of-the-art documents, laboatory analysis, economic assessment, bench and pilot studies, and full-scale field verification studies. Over the next five years the research will be reported as Technical Resource Documents in support of the RCRA Guidance Documents. These documents will be used to provide guidance for conducting the review and evaluation of land disposal permit applications. This paper will present an overview of this program and will report the current status of work in the following categorical areas:

A. Landfills

1. Multi-Layered Cover System
2. Waste Leaching
3. Clay Soil Liners
4. Flexible Membrane Liners
5. Waste Modification

B. Surface Impoundments

1. Assessment of Design
2. VOC Emissions
3. Containment Systems

C. Underground Mines

D. Dioxin Engineering

KEY WORDS

hazardous materials, pollution, environmental surveys, waste disposal, landfills, environmental engineering, environmental surveys, environmental tests, waste treatment, decontamination, containment, hydrogeology, leaching, linings

HAZARDOUS WASTE LANDFILL RESEARCH

U.S.E.P.A. PROGRAM

Norbert B. Schomaker

U.S. Environmental Protection Agency
Municipal Environmental Research Laboratory
Solid and Hazardous Waste Research Division
Cincinnati, Ohio 45268

This paper presents an overview of the hazardous waste landfill research program conducted by U.S.E.P.A.

INTRODUCTION

Congress, through the Solid Waste Disposal Act, also known as the Resource Conservation and Recovery Act (RCRA) PL 94-580, directed the Environmental Protection Agency to develop programs for the management of hazardous and non-hazardous solid wastes. To effect the degree of coordination required of such an endeavor, a committee was formed to prepare and update an Agency wide research strategy. The Solid and Hazardous Waste Research Committee coordinates the efforts of the Office of Research and Development (ORD) with those of the Office of Solid Waste (OSW), the Office of Enforcement (OE), the Office of Water Programs (OWP), the Office of Emergency and Remedial Response (OERR), and the EPA Regional Offices.

The Fiscal Year (FY) 1980 Solid and Hazardous Waste Research Strategy was based on the anticipated needs of the Agency as it implemented the mandates of RCRA. The major emphasis was placed on hazardous waste while continuing efforts in the municipal solid waste area. The FY 1981-1984 strategies focused entirely on hazardous wastes. In FY 1984, the Solid and Hazardous Waste Research Strategy Committee was combined with the Superfund Research Strategy Committee to form the Hazardous Waste/Superfund Research Strategy Committee.

Agency responsibilities under RCRA are reasonably specific, and future activities to fulfill those responsibilities have been scheduled according to a step-by-step strategy. Within this RCRA hazardous waste strategy, seven research categories have been established. The seven categories are:

- Waste Identification
- Waste Characterization (Assessment)
- Hazardous Releases (Spills)
- High Hazards (Dioxins)
- Incineration
- Land Disposal
- Alternative Technology (Treatment)

The above seven categories of research activities relating to RCRA are being investigated by various research groups within the USEPA. The hazardous waste landfill research program, which is the focus of this paper, is oriented

towards meeting the needs addressed in the land disposal category of this research committee. This research program is conducted by the Solid and Hazardous Waste Research Division, Municipal Environmental Research Laboratory, Environmental Research Center, Cincinnati, Ohio.

Land Disposal

The hazardous waste land disposal research program, encompassing state-of-the-art documents, laboratory analysis, bench and pilot studies, and full-scale field verification studies is at various stages of implementation. The objective of this program is to compile a more adequate data base of information so that current hazardous waste disposal technology to the land may be upgraded by (a) developing proper site selection design and operational criteria for the establishment of new waste disposal sites, and (b) developing proper control technology for upgrading existing waste disposal sites. The procedures thus developed will consider and describe those specific functions required to eliminate the pollution potential from landfills, surface impoundments, and underground mines used as hazardous waste storage facilities. Specific functions include the ability to predict or provide guidance for leachate quality and quantity, quick indicator tests for the selection of lining materials, quick indicator tests for chemical fixation performance and compatibility with various generic waste streams and a methodology for minimizing moisture infiltration.

Over the next 5 years the research will be reported as criteria and guidance documents for user communities. The land disposal research program is currently developing and compiling a data base for use in the development of guidelines and standards for waste residual disposal to the land as mandated by the RCRA. RCRA Guidance Documents, which provide guidance for conducting the review and evaluation of permit applications, are currently being prepared by the OSW in Washington, DC. Technical Resource Documents (TRD) in support of the Guidance Documents are also being prepared by the ORD in specific areas to provide best engineering technologies and methods for evaluating the performance of the applicant's design. The information and guidance presented in these documents will constitute a suggested approach for review and evaluation and should be useful references for design and operation.

The current FY 1984 hazardous waste land disposal research program has been divided into four general areas: (a) landfills; (b) surface impoundments; (c) underground storage; and (e) dioxin engineering.

LANDFILL

The landfill program examines components and unit operations of a hazardous waste landfill and optimizes their performance. The goal is to control and/or be able to predict the movement of liquids and gases in and around a landfill. The program develops basic information for each component and prepares reports of research and user documents for permit writers, design engineers, and operators.

The components and unit operations of a landfill to be addressed in this paper include:

- o multi-layered covered systems
- o waste leaching
- o clay soil liners
- o flexible membrane liners
- o waste modification

Multi-Layered Cover Systems

The objective of this activity is to develop and evaluate the effectiveness of various cover systems in relation to their functional requirements for actual field application. Validation efforts are being performed in the laboratory and field with model work development being pursued for eventual incorporation into a TRD.

The laboratory effort currently being pursued is evaluating alternatives to soil materials for use as landfill covers. Such materials as geomembranes, flexible membrane liners and waste materials are being investigated.

The model efforts relate to the assessment of time settlement/subsidence effects on cover systems and to the development and field verification of the two-dimensional subsurface drainage model entitled "Hydrologic Evaluation of Landfill Performance (HELP)." The time settlement/subsidence effort will

utilize a theoretical approach incorporating the classical consolidation theory and documented with practical field observations at existing sites. Computer models have been run to determine amounts of settlement based upon different scenarios. The HELP model has been developed into user friendly technical support information for establishment and evaluation of landfill performance. Field verification is currently being conducted for covers and leachate collection systems with large-scale physical models.

The field efforts being investigated relate to evaluating a three-layered surface cover system and investigating maintenance-free vegetative cover species. The three-layered surface cover system effort has resulted in plots being constructed where surface runoff, subsurface runoff, leachate formation and soil moisture distribution will be measured under applied rainfall. Also, a controlled level of subsidence will be generated and its effect on the cover integrity will be measured. The maintenance-free vegetative effort is examining the effects on cover integrity of deep-rooted vegetative growth with minimum maintenance.

The TRDs efforts are focusing on methods for control of infiltration to improve cover design and on the development of construction, maintenance and inspection manuals for clay liners/caps and leachate collection/cap drainage. The infiltration control effort is basically developing and compiling various methods to control infiltration into hazardous waste landfills. This information will be incorporated as updated material in the current TRD entitled "Evaluating Cover Systems for Solid and Hazardous Waste" (SW-867).

This document can be ordered from the Government Printing Office (GPO).* The GPO stock number is 055-000-00228-2. Another TRD document entitled "Hydrologic Simulation of Solid Waste Disposal Sites" (SW-868) describing a one-dimensional model of flow through a cover system has been printed by GPO. The stock number is 055-000-00225-8. The construction manual efforts are being pursued to provide guidance to insure proper installation and quality control during the construction of these multi-layered cover systems for hazardous waste landfills.

Waste Leaching

The objective of this activity is to develop and evaluate laboratory techniques for working with a sample of a waste or a mixture of waste to predict the composition of actual leachates obtained under field conditions. Results from laboratory and model predictions are being compared with results from pilot scale and field scale work to develop better procedures and an up-dated TRD on waste leaching.

*Superintendent of Documents
U. S. Government Printing Office
Washington, DC 20402
Phone (202) 783-3238

The laboratory effort is evaluating and comparing the effectiveness of batch extraction versus column leaching in generating leachate from four representative hazardous waste samples with diverse physicochemical characteristics. The model efforts relate to transit flow times and field capacity determination for water movement through wastes. The transit flow time effort is evaluating predictive methods for determining liquid flow rates through the landfilled wastes; conclusions are that deterministic predictive methods would be difficult to apply. The field capacity effort relates to developing a model for predicting saturation levels in landfills to determine the effectiveness of systems for controlling the production of leachate with time.

The field effort is determining the rate of release of pollutants from an actual field site and comparing the results with the model for predictive validation.

The TRD effort has produced a draft version on batch leaching procedures entitled "Solid Waste Leaching Procedure" (SW-924). The report was issued for public comment in March 1984. Appropriate comments will be incorporated into final publication by summer of 1984. Our previous TRD entitled "Landfill and Surface Impoundment Performance Evaluation" (SW-869) relating to leachate generation has been published and can be obtained from the GPO. The GPO stock number is 055-000-00233-9.

Clay Soil Liners

The objective of this activity is to evaluate the effectiveness of clay soils as liners and surface caps to contain or minimize leachate movement and infiltration and to predict performance with time. Laboratory and field studies are being performed to develop tools for predicting and evaluating performance of soil liners. Information produced will be published in TRDs and construction manuals.

The laboratory efforts are evaluating the effects of organic chemicals and inorganic leachates on clay soil liners. The organic chemical effort is assessing organic solvent effects on clay soil permeability and developing a matrix to predict soil/waste interaction. The inorganic leachate effort is evaluating the adverse impact of shrinkage on clay liner performance when selected inorganic salt solutions are placed in contact with the liner.

The methodology efforts are attempting to develop tools for predicting the retention and rate of movement of pollutants through soil liners. One effort relates to determining the effective porosity of soil and whether it is usable in a regulatory mode. Another effort is attempting to validate the precision and reliability of permeability (hydraulic conductivity) measurements as determined in the laboratory and in the field. A third effort relates to correlating the laboratory porosity measurements of both disturbed and undisturbed soils with similar soil samples in place in the field.

The field efforts are investigating the field testing of hydraulic conductivity for in-situ soils, and evaluating clay soil liner failures. The hydraulic conductivity effort is evaluating the effects of hydraulic gradient, gas diffusion, sample volume change and confinement on the measurements to determine permeability. The clay liner failure effort will evaluate actual in place or recompacted clay liners where organic chemicals have migrated through the clay liner and it has failed. Failure mechanisms will be identified.

The TRDs are focusing on the evaluation of clay soils for use as liners and on installation procedures. Also a manual is being developed to assist with proper construction, maintenance, and inspection for clay soil liner installations. The initial evaluation effort of clay soil liners has been published by the GPO in a TRD entitled "Lining of Waste Impoundment and Disposal Facilities" (SW-870). The GPO order number is 055-000-00231-2. The clay liner installation TRD will incorporate previous work on liquid control, waste leaching, pollutant movement and field quality assurance with the existing liner TRD report (SW-870) to produce a new guidance document. Two new TRD reports are currently published in draft for review by the public. These reports are entitled "Soil Properties, Classification, and Hydraulic Conductivity Testing" (SW-925) and "Procedures for Modeling Flow Through Clay Liners to Determine Required Liner Thickness" (EPA 530-SW-84-001). A third new TRD entitled "Batch Soil Procedure to Design Clay Liners for Pollutant Removal" will be completed in February 1985. The construction manual effort is being pursued to provide guidance to insure proper control during the construction of the clay soil liner control measure at hazardous waste landfills.

Flexible Membrane Liners

The objective of this activity is to evaluate the effectiveness of synthetic membrane or flexible membrane as liners and caps to contain leachates/moisture infiltration and to predict their performance with time. Efforts are being performed in the laboratory and the field for developing tools to establish flexible membrane liner performance criteria. Information produced will be published in TRDs and construction manuals.

The laboratory efforts are evaluating the adequacy of available laboratory testing procedures to determine hydraulic integrity of flexible membrane liners (FML). Also various liner/waste compatibility efforts are being pursued to determine the relationship between resistance to chemical modification and change in permeability of FML over a variety of time spans. One effort is compiling chemical resistance data from manufacturers and literature exposure data in conjunction with utilizing the cohesive energy density (CED) numbers to predict service life. A second laboratory effort is attempting to quantify leak rates through holes in FML.

The field efforts are investigating the strength and durability of seaming techniques and methods to repair damaged liners. The strength and durability effort is comparing the results obtained from lab studies of the fabricated material as supplied by the manufacturer to those results obtained from actual field applications. The repair effort is evaluating current repair techniques of patching and grouting FML materials and to identify other new repair

technqiues to improve the long term integrity of FML materials. One major field effort is an attempt to attain access to an operating hazardous waste disposal site for the purpose of pursuing various research tasks with respect not only to liners, but also to leachate collection, waste characterization and subsidence.

The TRDs are focusing on updating existing TRD's by pursuing efforts to expand the data base on FML and on developing liner compatibility guidance. The effort to expand the data base is correlating available information on existing FML types. These materials are also being subject to additional hazardous wastes and are being compared to overall performance. In the compatibility guidance effort, a liner acceptability ranking system is being developed from comparability of liner to waste data. The initial evaluation effort of FML has been published by the GPO in a TRD entitled "Lining of Waste Impoundment and Disposal Facilities" (SW-870). The GPO order number is 055-000-00231-2. Also in conjunction with the publication of this TRD, a leachate treatability TRD has been published entitled "Management of Hazardous Waste Leachates" (SW-871). The GPO order number is 055-000-00224-0. The construction manual effort is being pursued to provide inspection procedures and quality control criteria for the installation of flexible membrane liners at hazardous waste landfills.

Waste Modification

The objective of this activity is to evaluate the effectiveness of chemical stabilization and encapsulation processes as relates to improved handling; surface area reduction; limiting solubility; detoxify pollutants; and predicting performance with time. Validation efforts are being performed in the laboratory and field to correlate compatibility of the individual processes to specific waste types and to predict durability and leaching performance with time. Information produced will be published in a TRD.

The laboratory efforts are focusing on stabilization, encapsulation, and anaerobic degradation. The stabilization effort is assessing various stabilization processes to determine the effects of interfering materials (organics and inorganics) on process and product performance. Tests are being conducted on the fixed wastes to evaluate the degree of fixation, durability and strength, resistance to leaching and similar factors. The encapsulation effort is categorizing general encapsulation processes according to organic and inorganic binders such as epoxides, polyesters, vinyls and cement, calcium and silicates, respectively and evaluating their performance to the stated objectives. The anaerobic degradation effort is identified as a waste modification effort although it focuses on the use of microorganisms of multi-plasmid strains to enhance the degradation rate of organics at hazardous waste sites.

The field efforts are investigating a portable overpack/drum ensemble and providing technical assistance as needed. The ensemble effort is a portable truck mounted unit which involves overpacking existing metal containers with rotamolded polyethylene (PE) overpacks and friction welding a leak tight PE cover onto the overpack. Limited scale field demonstration has been performed at two sites. The technical assistance effort will provide the capability to respond to EPA needs in assessing processes for encapsulating, solidifying, and fixing hazardous waste.

The TRD is focusing on the state of the art of stabilization/solidification of industrial waste as a pretreatment process for disposal of hazardous waste. The initial TRD has been published by the GPO in a document entitled "Guide to the Disposal of Chemically Stabilized and Solidified Wastes" (SW-872). The GPO order number is 055-000-00226-6.

SURFACE IMPOUNDMENTS

The surface impoundment research program has been developed to provide a comprehensive understanding of the design, operation, and maintenance of surface impoundments as options for hazardous waste disposal. Information is being developed on the use of natural soils as liners and dikes. Also, the correlation of laboratory measurements with the construction standards achieveable in the field is being investigated. Of particular interest is the degree to which specification of construction techniques and inspection practice can influence uniformity and performance of the finished impoundment.

The components and unit operations of a surface impoundment to be addressed in this paper include:

- o Assessment of Design
- o VOC Emissions
- o Containment Systems

Assessment of Design

The objective of this activity is to develop a comprehensive understanding of the design, operation, and maintenance of surface impoundments and to predict performance under varying designs. Information thus obtained would be modeled to predict the success or failure of future designs. Efforts are being pursued by literature reviews, laboratory and field studies. Information produced will be published in TRDs.

The literature review effort is assessing design and operating practices for surface impoundment technology. Surface areas versus depth, types of liners, construction practices, monitoring, and depth control are some factors being determined.

The laboratory efforts are investigating the concerns and benefits of locating disposal facilities in unsaturated low-permeable soils as compared with saturated low permeable soils. Also, a technical assistance effort is being pursued to allow quick response to specific needs such as freeboard requirements and in-place closure of hazardous waste surface impoundments.

The field efforts are investigating success and failures of dike design, clay soil permeabilities and remedial action performance at surface impoundment sites. The success/failure effort is collecting data from specific owners/ operators and contractors to identify mechanisms which contribute to a surface impoundment success or failure. The clay soil permeability effort is being conducted at an actual working site and is attempting to verify the laboratory conclusions that organic chemicals affect the premeability of clay soils. The remedial action effort is evaluating the performance of various remedial actions at hazardous waste sites to compile and describe successful or unsuccessful methods that may be applicable to RCRA sites.

The TRDs are focusing on surface impoundment design, operation, maintenance and closure. The initial effort has focused on the closure aspects of surface impoundment and a TRD has been published by the GPO entitled "Closure of Hazardous Waste Surface Impoundments" (SW-873). The GPO order number is 055-000-00227-4. Another TRD entitled "Design, Construction, Maintenance and Evaluation of Clay Liners for Hazardous Waste Facilities" will be completed in 1985.

VOC Emissions

The objective of this activity is to identify and assess the volatilization of organic chemicals (VOC) from surface impoundments, determine pollutant release potential and to evaluate effectiveness of control technology techniques. Efforts are being pursued in the laboratory and the field to achieve this objective.

The laboratory effort is identifying volatilization mechanisms and parameters and developing techniques to measure these parameters. Models and predicative equations have been developed for these transport mechanisms and field validation studies are being pursued.

The field efforts are investigating wind dispersion and cover effectiveness. In the wind dispersal effort, assessment of gas volatilization is being investigated at actual disposal sites to determine effects of wind velocity, temperature and transfer coefficients. In the cover effectiveness effort, various control methods (synthetic membranes, soils, floatable materials) to minimize VOC emission release are being investigated at actual field sites by using previous developed measurement and modeling techniques.

The VOC emission area of activity for land disposal will be combined with VOC emission activities from incinerators and other disposal/treatment facility options to form a separate research category in FY 1986.

Containment Systems

The objective of this activity is to evaluate the effectiveness of soil dikes, liners and other components with or without the incorporation of synthetic liners, in containing hazardous sludges/liquids. Validation efforts are being performed in the laboratory and the field in relation to soil/waste interaction, hydraulic gradient, leak detection and hydrostatic forces. Information produced will be published in a TRD and construction manuals.

The laboratory efforts are evaluating contaminant/soil interaction, containment times, and hydraulic conductivity. The contaminant/soil interaction effort is performing batch type adsorption studies and using this data to estimate pollutant retention by earth material liners at hazardous waste disposal facilities. The containment times effort is comparing the accuracy and effort involved in using non-linear forms of the unsaturated water flow equation to evaluate clay liner function by predicting leachate containment times. The hydraulic conductivity efforts are investigating the relationships of laboratory and field compacted clay soil hydraulic conductivity values for various clay soils of different location and composition. Also, the effects of hydraulic gradient on the hydraulic conductivity will be tested and measured on several soils and permeants.

The methodology efforts are those techniques that have applicability to locating liner leaks. One effort is investigating the use of electrical resistivity for determining liner failures. The other effort is investigating innovative acoustical emission (AE) and time domain reflectrometry (TDR) for monitoring early detection of leaks in surface impoundment liners.

The field efforts are investigating leak detection and upward hydrostatic forces. The leak detection effort has verified at a one acre water filled site the electrical resistivity technique to locate leaks of 1, 5, and 12 in. diameter in size. The upward hydrostatic forces effort is evaluating the effects of hydrostatic pressure as exerted on various flexible membrane liners for a variety of point load conditions. Guidelines for installers will be

developed from this effort. Technical assistance is also being pursued to allow for quick responses to specific needs as developed in the hazardous waste surface impoundment program.

The TRD which was identified under the previous surface impoundment section entitled "Assessment of Design" also has application to this area of activity. Another effort which could develop into a TRD is investigating technical considerations in locating surface impoundments in low permeability soils whereby specific site conditions will be modeled to determine leachate movement. The construction manual effort is being pursued to provide guidance to insure proper control by use of quality assurance/quality control criteria during construction of surface impoundment dikes.

UNDERGROUND MINES

The objective of this activity is to update the state-of-the-art technology on the use of underground mines for emplacement of hazardous waste. Efforts are being pursued both by literature review and planned field demonstration.

The literature review effort is updating the status of underground mine usage for hazardous waste emplacement from both the technical and economic feasibility viewpoints. Cost information is included to compare economics of various other disposal options.

The field effort was planned to participate with an owner of either an active or inactive mine in demonstrating on a limited scale the feasibility of this disposal concept in the USA. This effort has been delayed.

DIOXIN ENGINEERING

The objective of this activity is to provide a data base of information for input into the preparation and implementation of the National Dioxin Strategy to prevent further dioxin releases into the environment from contaminated sites. Validation studies are being performed in the laboratory and the field as relates to dioxin desorption, dioxin leachability and fugitive dust emissions.

In the laboratory efforts of desorption and leachability, the desorption effort is determining the extent and rate of release of dioxin from three contaminated soils by use of batch and column elution of the soils with water and selected solvents. The leachability effort is investigating the effects of stabilizing dioxin contaminated soils with a bituminous and cement additive to minimize the leachability aspects as compared to nonstabilized soil.

The field effort is investigating a variety of dust suppresants to minimize fugitive dust emissions from dioxin contaminated soils during application of various trafficking loads.